APPENDIX B

Radionuclides In Sewage Sludge and Ash at POTW Test Sites and Comparison With Other Sources of Radioactivity

The purpose of this Appendix is to compare published data on typical concentrations of radionuclides in soil, fertilizer, and building materials to the concentrations of radionuclides found in the sludge and ash samples of a pilot study of nine Publicly Owned Treatment Works (POTWs). The pilot study was conducted by a federal interagency working group (Interagency Steering Committee on Radiation Standards (ISCORS)) to develop sampling and analysis procedures for a nationwide survey of radionuclide concentrations in municipal sewage sludge and incinerator ash, to be conducted in 1999.

Over the last several decades, the U.S. Environmental Protection Agency (EPA) has conducted surveys of sewage sludge, ash, compost, and the other products produced by POTWs, to determine whether concentrations of pollutants that may pose a danger to members of the public or POTW workers are present. Recently, the U.S. Nuclear Regulatory Commission (NRC), the U.S. Department of Energy (DOE), and the U.S. Department of Defense (DOD) have begun a collaborative effort with EPA to conduct a survey of POTWs nationwide to determine potential concentrations of naturally-occurring and commercially utilized sources of radioactive materials in the sludge or ash. The results of this survey will be available in about 2 years.

A pilot study of nine POTWs was conducted to assist the agencies in developing sampling and analysis procedures. It is important to note that the purpose of this pilot study was not to assess the relative safety or hazard of radioactive materials in sewage sludge and incinerator ash, but rather to assess the sampling and analysis procedures. As such, no conclusions were drawn as to the relevance of radioactive material concentrations detected in these samples. This document is intended to help put these raw data in perspective.

SOURCES OF RADIATION EXPOSURE

Radiation in the environment from natural sources is the major source of radiation exposure to man. Radiation exposure results from the naturally-occurring radionuclides in the environment (terrestrial radiation) and direct cosmic (extra-terrestrial) radiation. Naturally-occurring radionuclides are present in some plants and animals. In the human body, for example, radioactive potassium (K-40) is present in bones and soft tissues and is the principal naturally-occurring source of internal radiation exposure. Some sources of natural radiation have been enhanced (concentrated) by human technological activities and include wastes from mineral ores and the petroleum industry, sludge and scale from drinking water treatment, and articles made from naturally-occurring radioactive materials such as thorium in lantern mantles. Together, this radiation is often referred to as "natural" or "background" radiation. It is all around us and cannot be completely avoided. In addition to natural or background radiation, radiation from man-made sources, such as X-ray machines and nuclear reactors and fallout from nuclear weapons testing in the past, also results in a relatively small source of radiation exposure to man.

Naturally-occurring radioactive materials are found in soil and water as well as in materials used to build our homes, such as bricks and stones. Geological formations and soils may contain isotopes of uranium, thorium, radium, radon, and other radioactive elements. The public is generally aware of the radioactive gas, radon (radon-222), which is one of the decay products of the uranium isotope uranium-238 that is found naturally in soil. Radon is often found in the air we breathe and the water we drink. Radon-222 and its decay products contribute most of the radiation exposure received by members of the public.

RADIOACTIVE MATERIALS IN SEWAGE SLUDGE, ASH AND OTHER PRODUCTS

Sewage sludge and ash at POTWs may contain both naturally-occurring and man-made radioactive materials. Water that originates in or moves through geologic deposits containing naturally-occurring radionuclides could result in radioactivity being carried to the treatment facility with storm water runoff or infiltration entering the sewer system, and water treatment plant residuals discharged to the sewer system. Industrial, medical or research facilities may also discharge radioactive materials to the sanitary sewer system in accordance with prescribed State and Federal regulations. In addition, radioactive materials administered to patients for the diagnosis or treatment of illnesses are excreted into the sewer system. Other industrial or residential discharges (such as fertilizer residues) can contain naturally-occurring radioactive materials that are not subject to licensing or regulation.

Tables 1 and 2 provide the concentrations of radionuclides detected during the pilot survey of sludges and ash from nine POTWs, as well as typical ranges of radionuclide concentrations commonly found in U.S. soils and common items such as fertilizers and building materials. The curie (Ci), or fractions of a curie (e.g. picocurie), is the unit for expressing a quantity of radioactivity. The unit normally used to describe the concentrations of radioactivity in the environment is picocuries per gram (pCi/g). A picocurie is one one-trillionth (1/1,000,000,000,000) of a curie. Radionuclide concentrations in these tables have been rounded to the nearest decimal point. Values in these tables do not show uncertainty calculations. Sludge and ash samples from POTWS associated with facilities known to discharge man-made radionuclides were included in the pilot survey. Inclusion in these tables does not imply that the range of radionuclide concentrations presented for the materials is protective of human health.

The ISCORS agencies make no representation as to human or environmental health and safety significance from exposure to radionuclides in the concentrations described in the tables. Further information may be obtained from Robert Bastian at EPA (email bastian.robert@epa.gov or phone 202-260-7378), Behram Shroff at EPA (email schroff.behram@epa.gov or phone 202-564-9707) or Mary Thomas at NRC (email mlt1@nrc.gov or phone 301-415-6230).

Table 1

Pilot Survey Concentration Ranges and
Typical U.S. Background Concentrations of Radionuclides
in Soil, Fertilizer, and Common Building Materials
(*All values are in pCi/g-dry weight)*

Radio-nuclide	Soil [1]	Phosphate Fertilizer [2]	Building Materials [1]	Pilot Study Sludge	Pilot Study Ash
Am-241	NDA[3]	NDA	NDA	ND[4]	ND
Ba-140	NDA	NDA	NDA	ND	ND
Be-7 *	NDA	NDA	NDA	ND - 22	4.0 - 13
Bi-212	0.1 - 3.5	0.1 - 4.6	0.1 - 3.7	ND - 2.0	ND - 2.0
Bi-214	0.1 - 3.8	4.0 - 140	2.5 - 5.05	ND - 2.0	.02 - 16
C-14 *	NDA	NDA	NDA	ND	ND
Co-60	NDA	NDA	NDA	ND - 6.0	ND
Cr-51	NDA	NDA	NDA	ND - 4.0	ND
Cs-137	0.1 - 0.2[6]	NDA	NDA	ND - 1.0	0.03 - 0.08
H-3 *	NDA	NDA	NDA	ND - 1.75	ND
I-125	NDA	NDA	NDA	ND - 1.0	ND - 0.3
I-131	NDA	NDA	NDA	ND - 70	ND - 4.0
K-40 *	2.7-19	32 - 160 [7]	0.8 - 30	2.0 - 8.0	14 - 16
Pa-234m *	0.1 - 3.8	4.0 - 140	0.2 - 5.0[5]	ND - 15	ND - 9.0
Pb-212 *	0.1 - 3.5	<0.1 - 4.6	0.1 - 3.7	0.2 - 2.0	1.0 - 2.0
Pb-214 *	0.1 - 3.8	4.0 - 140	0.2 - 5.0	ND - 2.0	2.0 - 17
Pu-238	NDA	NDA	NDA	ND - 0.03	ND - 0.01
Pu-239	NDA	NDA	NDA	ND - 0.08	ND - 0.01
Ra-223 *	<0.1 - 0.2	0.2 - 6.6	<0.1 - 0.2[5]	ND - 0.06	ND
Ra-224 *	0.1 - 3.5	<0.1 - 4.6	0.1 - 3.7[1]	ND - 1.0	0.5 - 4.0
Ra-226 *	0.1 - 3.8	0.1 - 24	0.1 - 3.5	1.0 - 29	3.0 - 25
Ra-228 *	0.1 - 3.5	<0.1- 4.6	0.1 - 3.7	ND - 2.0	2.0 - 9.0

Radio-nuclide	Soil [1]	Phosphate Fertilizer [2]	Building Materials [1]	Pilot Study Sludge	Pilot Study Ash
Sr-89	NDA	NDA	NDA	ND - 7.0	ND - 0.8
Sr-90	NDA	NDA	NDA	ND - 0.7	ND
Th-227 *	<0.1 - 0.2	0.2 - 6.6	<0.1 - 0.2	ND - 0.1	ND
Th-228 *	0.1 - 3.5	<0.1 - 4.6	0.1 - 3.7	ND - 1.0	ND - 2.0
Th-230 *	0.1 - 3.8	4.0 - 140	0.2 - 5.0	ND - 1.0	0.5 - 2.0
Th-232 *	0.1 - 3.5	<0.1 - 4.6	0.1 - 3.7	0.01 - 0.9	0.4 - 1.0
Th-234 *	0.1 - 3.8	4.0 - 140	0.2 - 5.0	ND - 12	2.0 - 5.0
Tl-201	NDA	NDA	NDA	ND - 24	ND
Tl-208 *	0.1 - 3.5	<0.1 - 4.6	0.1 - 3.7	ND - 0.5	ND - 0.6
U-234 *	0.1 - 3.8	4.0 - 140	0.2 - 5.0	0.2 - 44	5.0 - 8.0
U-235 * [8]	<0.1 - 0.2	0.2 - 6.6	<0.1 - 0.2	ND - 3.0	ND - 1.4
U-238 *	0.1 - 3.8	4.0 - 140	0.2 - 5.0[5]	0.2 - 12	2.0 - 5.0

NOTES:

1. R. Tykva and J. Sabol, "Low-Level Environmental Radioactivity - *Sources and Evaluation,*" Technomic Publishing Company, Inc., Lancaster, Pennsylvania (1995). This reference is the source of data for concentrations of radionuclides in soil and building materials except for the concentrations of U-238, U-235, and Cs-137 which came from references 5 and 6, respectively. The concentrations of the daughters or decay products of U-238, such as Th-234, Ra-226, etc., those of U-235, such as Th-227 and Ra-223, and those of Th-232 are set equal to those of their respective parent radionuclides by assuming that the daughters are in secular radioactive equilibrium with the parent radionuclides.

2. Source for data on fertilizers: National Council on Radiation Protection and Measurements, 1987, Radiation Exposure of the U.S. Population from Consumer Products and Miscellaneous Sources; NCRP Report No. 95, pp. 24-32. This is the source of data for the concentrations of radionuclides in fertilizers except for the concentration of K-40 in soil which came from the reference in note 7.

3. NDA - No data available

4. ND - Not detected. The radionuclide was not detected in some of the samples during the pilot study. For detection limits for radionuclides, see the tables in "Report to the ISCORS Subcommittee on the Sewage Nuclide Concentration Test Samples," dated

November 23, 1998**.**

5. M. Eisenbud and T. Gesell, “Environmental Radioactivity,” Fourth Edition (1997), Academic Press, New York, New York.

6. Cs-137 concentration range in soil obtained from Figure 4-4, p. 94 of NCRP Report No. 50, “Environmental Radiation Measurements,” Recommendations of the National Council on Radiation Protection and Measurements (1976).

7. Source for data on K-40 in fertilizer: S. Cohen and Associates, 1997, Final Draft NORM Waste Characterization; EPA Contract No. 68D20155, WA No.5-09, pp. B-3-1 to B-3-24.

8. Values for U-235 in soil, fertilizer and building materials were based on the concentrations of U-238 in the same materials and the natural ratio of U-235 to U-238.

9. The symbol “<“ which appears throughout the table is an abbreviation for the words “less than”.

10. * - naturally-occurring radionuclide

Table 2 -
Pilot Survey Radionuclide Concentrations in Sewage Sludge and Ash
(All values are in pCi/g-dry weight)

NUCLIDE	SEWAGE SLUDGE SAMPLE RESULTS	ASH SAMPLE RESULTS
Am-241	ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND	ND, ND, ND, ND, ND, ND, ND
Ba-140	ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND	ND, ND, ND, ND, ND, ND, ND
Be-7	3.2, 3.08, 2.16, 2.8, 2.21, 2.26, 1.04, 0.72, 0.13, 0.11, 0.16, ND, 0.72, 0.47, ND, ND, 0.69 , 0.42, 0 .76, 0.76, 7.15, 8.73, 1.30, 1.13, 22.1, 21.9, 18.5, 14.2, ND, ND	4.09, 12.7, 4.25, 4.23, 5.12, 5.34, 5.21
Bi-212	ND, ND, ND, 0.81, ND, ND, ND, ND, ND, 0.18, ND, 0.55, ND, ND, ND, ND, ND, 0.37, ND, 0.47, ND, 0.50, ND, 1.49, ND, 0.76, ND, 0.63, ND, 0.56	ND, 0.81, ND, ND, 1.24, ND, 1.54
Bi-214	0.68, 0.49, 0.47, 0.47, 1.12, 0.61, 0.26, 0.38, 0.21, 0.13, 0.25, 0.24, 0.26, ND, 1.38, 0.40, 1.69, 2.24, 0.45, 0.48, 0.92, 0.57, 1.37, 0.40, 0.40, 0.25, 0.41, 0.22, 0.35, 0.19	3.15, 2.08, 3.12, 9.94, 15.5, 13.7, 15.8
C-14	ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND	ND, ND, ND, ND, ND, ND, ND
Co-60	ND, 0.12, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, 6.47, 5.07, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND	ND, ND, ND, ND, ND, ND, ND
Cr-51	ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, 3.54, ND, ND, ND, ND, ND, 1.38, ND, ND	ND, ND, ND, ND, ND, ND, ND
Cs-137	0,.30, 0.35, 0.07, ND, ND, 0.05, 0.06, ND, 0.03, 0.01, 0.03, 0.02, 0.02, ND, 1.08, 1.09, 0.02, 0.02, ND, ND, 0.06, 0.06, 0.20, 0.18, 0.05, 0.05, 0.08, 0.03, 0.02, 0.02	0.03, 0.08, 0.04, 0.05, 0.08, 0.04, 0.05
H-3	ND, ND, ND, ND, ND, ND, 30.4, ND, 3.75, ND , ND, ND, 1.69, ND, ND, ND, ND, ND, ND, ND, 1.75, ND, ND, ND, ND, ND, 1.65, ND, ND, ND	ND, ND, ND, ND, ND, ND, ND
I-125	ND, ND, 0.91, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND	ND, ND, ND, 0.26, ND, ND, ND
I-131	60.5, 69.8, 0.49, 0.47, 0.49, 0.49, 13.8, 14.2, ND, ND, ND, ND, 7.47, 13.7, 0.26, 0.71, 0.95, 0.96, 37.4, 38.5, 0.28, 0.51, ND, ND, 9.25, 5.14, 5.55, 2.59, ND, ND	0.16, 4.25, 0.16, 4.18, ND, ND, ND
K-40	4.99, 6.23, 2.97, 3.32, 2.80, 3.29, 3.45, 4.74, 7.70, 4.99, 7.74, 7.08, 3.33, 2.77, 2.22, 2.00, 7.36, 7.87, 2.15, 2.54, 5.04, 5.52, 5.74, 5.51, 4.54, 4.76, 5.12, 4.41, 6.88, 7.29	15.2, 15.4, 15, 14.2, 14.4, 14.4, 15.6
Pa-234m	ND, 9.47, ND, ND, ND, ND, 9.55, ND, 2.37, 1.90, 13.2, 11.4, 11.1, 9.33, 14.9, 11.4, ND, ND, ND, ND, ND, 1.36, ND, 2.64, ND, 3.19, 1.17, 2.49, 10.1, 10.5	8.52, 4.02, 6.21, 2.44, ND, ND, 3.37
Pb-212	0.18, 0.27, 0.57, 0.74, 0.59, 0.56, 0.25, 0.31, 0.25, 0.18, 0.56, 0.63, 0.25, 0.24, 0.22, 0.28, 0.51, 0.60, 0.23, 0.35, 0.49, 0.55, 1.55, 1.53, 0.68, 0.75, 0.80, 0.65, 0.52, 0.55	1.39, 0.91, 1.42, 1.50, 1.94, 1.61, 1.85
Pb-214	0.42, 0.47, 0.59, 0.50, 0.94, 0.45, 0.32, 0.34, 0.25, 0.14, 0.30, 0.24, 0.22, ND, 0.32, 0.29, 1.76, 2.35, 0.39, 0.43, 1.00, 0.63, 1.42, 0.44, 0.38, 0.19, 0.46, 0.24, 0.34, 0.22	3.40, 2.23, 3.42, 11.1, 16.6, 14.6, 17.3
Pu-238	ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, 0.02, 0.02,	0.01, ND, ND, ND,

	ND, ND, ND, ND, ND, ND, ND, ND, 0.03, ND, ND, ND, ND, ND	ND, ND, ND
Pu-239	ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, 0.02, 0.08, 0.04, ND, ND, ND, ND, ND, 0.04, 0.07, 0.01, ND, ND, ND, ND, 0.01, ND	ND, ND, ND, ND, ND, 0.01, ND
Ra-223	ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND ND, ND ND, ND, ND, ND, ND, 0.06, ND, ND, ND, ND, ND, ND, ND, ND	ND, ND, ND, ND, ND, ND, ND
Ra-224	ND, ND, ND, ND, ND, ND, ND, ND, ND, 0.19, ND, 0.70, ND, ND, ND, ND, ND, 0.43, ND, ND, ND, 0.49, ND, 1.46, ND, 0.62, ND, ND, ND, 0.59	ND, 0.49, ND, ND, 3.72, ND, 3.31
Ra-226	4.65, 6.19, 1.46, 3.02, 2.36, 1.71, 5.11, 7.82, 1.46, 1.13, 8.92, 1.80, 10.1, 10.6, 29.2, 6.38, 3.61, 4.53, 2.13, 4.08, 2.00, 2.55, 3.09, 3.42, 2.36, 3.25, 2.67, 2.65, 7.83, 1.97	8.34, 2.92, 9.36, 16.7, 25.0, 17.7, 25.1
Ra-228	0.66, ND, 1.05, 1.23, 0.61, 0.86, 0.74, 0.70, 0.37, 0.20, 0.67, 0.70, 0.91, 0.55, 0.46, 0.60, 1.52, 1.60, 1.20, 1.48, 1.24, 1.22, 1.95, 1.77, 1.19, 1.14, 1.40, 1.11, 0.64, 0.66	1.84, 1.58, 1.85, 7.81, 8.60, 8.20, 8.88
Sr-89	ND, ND, ND, ND, 7.12, ND, ND, ND, ND, ND, ND, ND, ND, ND, 1.17, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, 0.56, ND, ND, ND	0.75, ND, ND, ND, ND, ND, ND
Sr-90	ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, 0.57, 0.74, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND	ND, ND, ND, ND, ND, ND, ND
Th-227 alpha	ND, ND, ND, 0.05, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, 0.07, ND, ND, ND, 0.06, ND, 0.07, ND, ND	ND, ND, ND, ND, ND, ND, ND
Th-227 gamma	ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND	ND, ND, ND, ND, ND, ND, ND
Th-228	0.80, 0.52, 0.14, 0.62, 0.49, 0.50, 0.29, ND, 0.48, 0.24, 0.45, ND, 0.30, 0.47, 0.24, ND, 0.78, 0.54, 0.47, ND, 0.67, 0.63, 1.39, 0.91, 0.73, 0.71, 0.92, 0.83, 0.49, ND	1.30, ND, 1.13, 2.42, 2.04, 1.65, 1.44
Th-230 alpha	ND, 0.41, 0.16, 0.62, 0.57, 0.58, 0.35, 0.32, 0.42, 0.23, 0.25, 0.33, 0.22, 0.24, 0.16, 0.40, 0.29, 0.29, 0.11, 0.19, 0.53, 0.49, 0.78, 1.07, 0.84, 0.54, 0.99, 0.60, 0.30, 0.43	2.36, 0.99, 2.17, 0.74, 0.72, 0.55, 0.87
Th-230 gamma	ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND	ND, ND, ND, ND, ND, ND, ND
Th-232	0.20, 0.26, 0.11, 0.40, 0.30, 0.36, 0.19, 0.35, 0.35, 0.18, 0.23, 0.42, 0.18, 0.27, 0.10, 0.15, 0.24, 0.43, 0.01, 0.01, 0.34, 0.39, 0.92, 0.91, 0.45, 0.55, 0.56, 0.49, 0.28, 0.27	1.19, 0.66, 1.02, 0.48, 0.71, 0.50, 0.35
Th-234	5.00, 5.43, 1.39, ND, 1.48, ND, 5.28, 2.79, 1.88, 0.83, 12.5, 11.9, 7.78, 3.19, 11.8, 7.54, 0.53, ND, 0.42, ND, 0.86, 0.86, 1.58, 1.00, 1.29, 2.18, 1.25, ND, 1.09, 10.6	5.03, 3.70, 5.08, 2.37, 2.42, 4.17, 2.09
Tl-201	ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, ND, 14.0, ND, ND, ND, 4.19, ND, 23.6, ND, ND, ND, ND, ND, 21.5, ND, 5.51, ND, ND	ND, ND, ND, ND, ND, ND, ND
Tl-208	ND, 0.1, ND, 0.26, ND, 0.19, ND, 0.09, ND, 0.06, ND, 0.20, ND, 0.06, ND, 0.05, ND, 0.17, ND, 0.11, ND, 0.17, ND, 0.51, ND, 0.24, ND, 0.22, ND, 0.18	ND, 0.29, ND, ND, 0.65, ND, 0.61
U-234	14.4, 6.95, 0.21, 0.81, 0.98, 0.98, 13.2, 11.8, 4.93, 2.62, 12.2, 12.3, 15.4, 12.7, 44.5, 43.8, 1.46, 1.24, 4.44, 1.61, 1.36, 1.31, 1.61, 2.00, 1.84, 1.76, 1.56, 1.51, 10.9, 10.8	5.16, 5.43, 5.78, 7.34, 7.34, 7.62, 6.01
U-235 alpha	0.55, 0.75, 0.01, 0.03, 0.19, 0.05, 0.35, 0.66, 0.16, 0.12, 0.50, 0.43, 0.58, 0.68, 1.81, 3.06, 0.03, 0.08, 0.15, 0.08, 0.09, 0.09, 0.13, 0.13, 0.17, 0.07, 0.21, 0.09, 0.49, 0.57	0.20, 0.42, 0.18, 0.18, ND, 0.14, 0.24
U-235 gamma	0.20, ND, ND, ND, ND, ND, 0.41, 0.48, 0.04, 0.07, 0.56, 0.52, 0.50, 0.64, 1.87, 2.04, ND, ND, ND, ND, 0.07, 0.15, 0.05, ND, 0.10, ND, 0.14, ND, 0.50, 0.46	0.32, 0.22, 0.34, 0.12, ND, ND, 1.39
U-238	10.3, 5.83, 0.18, 0.75, 0.90, 0.85, 6.72, 6.23, 2.74, 1.46, 9.77, 9.62, 12.5, 10.0, 11.5, 12.0, 0.74, 0.71, 0.95, 0.73, 1.23, 1.15, 1.06, 1.21, 1.33, 1.36, 1.41, 1.13,	4.25, 3.81, 4.75,

	8.63, 8.33	3.26, 3.86, 3.33, 2.28
Gross Alpha[1]	21.0, 18.6, 5.0, 5.73, 5.19, 8.78, 13.4, 19.0, 5.17, 7.55, 18.5, 30.8, 23.7, 19.5, 50.8, 48.9, 12.6, 11.7, 16.4, 22.6, 8.70, 13.6, 14.9, 23.9, 10.2, 12.7, 10.5, 10.7, 19.8, 28.5	24.4, 46.5, 41.0, 82.3, 97.9, 92.6, 72.9
Gross Beta[1]	30.8, 22.1, 10.9, 8.58, 12.1, 9.36, 20.4, 15.5, 13.8, 10.8, 29.8, 26.2, 35.3, 21.3, 60.1, 34.8, 19.0, 15.3, 16.8, 10.5, 17.1, 15.9, 22.5, 16.5, 19.0, 12.5, 18.4, 16.8, 34.4, 24.6	51.5, 28.6, 51.4, 77.6, 65.4, 95.4, 47.2

NOTES:

1. Gross alpha and Gross beta – These measurements are generally used as indicators of the presence of alpha and beta emitting radionuclides in a sample. Gross alpha and gross beta activity analyses are used to screen samples to determine the need for nuclide-specific analyses. They were included in the pilot study, but have no corresponding background levels, and thus are not included in Table 1.

ND - Not detected. The nuclide was not detected in some of the samples during the pilot study. See the tables in the EPA National Air and Radiation Environmental Laboratory "Report to the ISCORS Subcommittee on the Sewage Nuclide Concentration Test Samples," November 13, 1998, for detection limits for nuclides.